

quake waves, the author described the "time-take," which is a clock which is an automatic arrangement causing dots to be made and the time of wave-motion to be indicated without stopping the clock. He describes shocks observed by him in Japan as travelling at 10,000 feet per second, decreasing as it went on to 4500 feet, getting slower and slower as it went on. The waves last from thirty seconds to four minutes. The author describes the result of experiments carried out by himself and Mr. Gray as to artificial earthquakes, explosions of 2 lbs. to 5 lbs. of dynamite in bore-holes 10 feet in depth, fired by electricity, and the effect of letting a heavy iron ball fall on the ground to a depth of 20 to 30 feet in height. The effect of shocks is communicated along the surface, gradually decreasing as it proceeded from the point of propagation, but at a less rate as the distance increases.

SECTION A—MATHEMATICAL AND PHYSICAL

On the Absolute Measurement of Electric Currents, by Prof. Lord Rayleigh.—The absolute measurement of current is more difficult than that of resistance. All the methods hitherto employed require either accurate measurements of the horizontal intensity of the earth's magnetism or of coils of small radius and many turns. This latter is difficult to evaluate, as it is impossible to measure the length of the wire wound, as the tension necessary to make the wire lie evenly, stretches it very considerably, whilst it is most important to determine the mean radius accurately, as an error therein doubles itself in the final result. The method of Kohlrausch is free from this objection, but it requires a knowledge of the moment of inertia, a quantity not easy accurately to determine. When the electromagnetic action is a simple force, it can be determined directly. In Mascart's recent determination, a large solenoid is suspended vertically in a balance, and is acted on by a flat co-axial coil of much larger radius. This is simple to think about, but not calculated to secure precise results. The appearance of accuracy is illusory, unless it can be assumed that the distribution of wire is absolutely uniform. It would appear that all the turns of the suspended coil should operate as much as possible, that is, that the suspended coil should be compact, and should be placed in the position of maximum effect. There is a further incidental advantage in this arrangement. The expression for the attraction involves as factors the product of the number of turns, the square of the current, and a function of the mean radii of the two coil, and of the distance between their mean planes. This function is of no dimensions. When the position is such that the function for two given coils is a maximum, the result is practically dependent only on the two mean radii, and the function being of no dimensions, can involve these mean radii only in the form of a ratio. This can be obtained electrically with full precision by dividing a current between them in such a way that no effect is produced on a small magnet at their common centre. In practice it will be desirable to duplicate the fixed coil, placing the suspended coil midway between two similar fixed ones, through which the current passes in opposite directions.

On the Duration of Free Electric Currents in a Conducting Cylinder, by Lord Rayleigh.—This paper was devoted to considering the rate of decay of currents of electricity circulating round a conducting cylinder. The time in which the intensity sinks from e to 1 is called the "time of subsidence." For a copper cylinder of r centimetres radius, this is equal to $r^2/800$. That this may be one second, the diameter of the cylinder must be two feet.

On the Equilibrium of Liquid-conducting Surfaces charged with Electricity, by Lord Rayleigh.—This was a mathematical paper in which was investigated the condition of stability of a sphere of fluid charged with electricity. If Q be the charge, T the surface tension of the fluid, and a the radius of the sphere, then the condition of stability is that $T > Q^2/16\pi a^3$.

Preliminary Account of Results obtained during the late Total Solar Eclipse, by Prof. Schuster and Capt. Abney.—Three photographs of the corona were obtained with different exposures. The comet Tewfik, discovered during the eclipse, appears on the photographs, and the change of its position in successive plates shows that it was moving away from the sun. The corona is seen to extend over a solar diameter away from the sun. A plate exposed in a camera which had a prism in front of the lens shows the spectra of different prominences, which are not found to be identical, but in every case the lines H and K are

the strongest. A photograph obtained in a complete spectro-scope shows (1) a complicated prominence spectrum; (2) a strong continuous spectrum in the lower parts of the corona; (3) a reversal of the solar line G in the upper regions; (4) a series of coronal lines, different from the prominence lines.

Some Matters relating to the Sun, by Prof. Schuster.—Observations of the shape assumed by the solar corona in successive eclipses during the last fifteen years have shown remarkable changes coincident with the sun-spot period. The corona of sun-spot minimum is characterised by a certain symmetry about an axis not far removed from the sun's axis of rotation, but very likely not quite coincident either with it or with the perpendicular to the ecliptic plane. Some apparent irregularities in the symmetry seem to be due to differences in the position of the earth in its annual orbit. Changes in the spectroscopic and polariscopic properties of the corona which are coincident and connected with the changes of form seem to point to partly meteoric origin of the corona.

On a Misprint in the Tidal Report for 1872, by Mr. G. H. Darwin.—Mr. Darwin has recently been carrying out a laborious reduction, by the Method of Least Squares, of the observations of the tides of long period at a number of stations. The results, which seem to have an important bearing on the question of the rigidity of the earth's mass, will appear as § 848 in the new edition of Thomson and Tait's *Natural Philosophy*, now in the press. Subsequently to the completion of the calculations, Prof. J. C. Adams discovered a misprint in the Tidal Report of 1872, which forms the basis for the method of harmonic analysis, which has been applied to the tidal observations. On inquiry of Mr. Roberts, who has superintended the original computations, Prof. Adams learnt that the erroneous formula has been used in all the reductions of the long period tides. The erroneous formula occurs near the middle of p. 471 of the Report of the British Association for 1872, in the instructions for clearing the diurnal means from the undue influence of the short period tides; in the first of the two formulæ for that purpose, the factor $\sin 12n/\sin \frac{1}{2}n$ should obviously be replaced by $\sin 24n/\sin n$. The tides of long period are evaluated by the following process:—A mean is taken of the twenty-four heights of the water above the datum line at each mean solar hour during the twenty-four hours. The 365 diurnal means form the results of tidal observation for the whole year, and these are to be treated by harmonic analysis; but the continuous integrals which arise in Fourier's method are of course replaced by finite integrals. This method of procedure introduces an undue influence of the short period tides on the values deduced for the long tides, and a correction to each diurnal mean is necessary to get rid of this influence. It is in the formula for the correction to be applied in the case of the semi-diurnal tides that the error occurs. This paper is an evaluation of the maximum effect which can have been exercised on the results by the error. The analysis shows that all the values assigned to the long period tides in the Tidal Reports and Tide Tables must have been more or less vitiated. The lunar fortnightly declinational tide, the semi-annual and the annual tide have suffered comparatively little. The monthly elliptic tide has suffered more, and the synodic fortnightly tide will in many years have been utterly worthless. The paper contains suggestions of a new method of procedure in the harmonic analysis of the tides of long period, and also discusses a remarkable result of the procedure by diurnal means in consequence of which there is an exaggeration of the undue influence exercised by the short-period tides on those of long period, in which either the sum or difference of the speeds is exactly 15° or 30° per mean solar hour.

On the Velocity of White and Coloured Light, by Mr. G. Forbes.—The author gave an account of experiments made by him in conjunction with Dr. James Young, F.R.S., with a view to determining the velocity of light. This research has been published in the *Transactions of the Royal Society*. The chief point of interest is that it appears that the velocity of blue light is greater than that of red, the difference being between 1 and 2 per cent. of the whole velocity.

Lord Rayleigh could give no other possible explanation of the phenomena described by Mr. Forbes, but he had great hesitation in accepting them from considerations on other sides. Michelson altogether repudiated them, and Lord Rayleigh thought that Foucault's method, that used by Michelson, was better suited to bring out results, if such existed, than Fizeau's, for it would produce a spectrum of considerable length. He would refer to some other points which he noticed in a letter to NATURE about twelve months ago, especially as to what is

meant by the velocity of propagation of a wave. In a regular train of waves this was the velocity with which any given phase of a wave moved forward; this could easily be observed in the case of waves on water, but in the case of light no wave form could be observed. The velocity determined by Fizeau's method, or by the eclipses of Jupiter's satellites, was not this, but the velocity of propagation of intermissions of light, which if the true velocity of propagation is a function of the wave-length, is not the same as the true velocity; it is only the same where, as in the case of air, the velocity of propagation is the same for all wave-lengths. Foucault's method (Michelson's) is based on determining the angular motion of a mirror between successive reflections, which again is a different quantity from the former two.

Sir W. Thomson wished to testify that the experiments were made most carefully, and felt unable to suggest any other explanation than Mr. Forbes's, but he felt strong previous objections to accepting it. He pointed out that Mr. Forbes's observations made the velocity of propagation smaller for waves of shorter period, whilst from the analogy of sound in elastic bodies we should expect the opposite.

SECTION B—CHEMICAL SCIENCE

On the Reversals of the Spectral Lines of Metals. By Professors Liveing, M.A., F.R.S., and J. Dewar, M.A., F.R.S.—The authors have a twofold object in view in the study of this subject, (1) to trace the parallel between the condition of the elements as they exist in the sun and those in which they may be placed on the earth; (2), that a knowledge of the reversible lines might aid to distinguish those due directly to the vibrations of the molecules and those produced by superposition of waves or by some strain upon the molecules, such as the electric arc might produce. They classify the reversals, as follows; (1) Reversals produced when the expanded line itself forms the background against which the absorption line is narrowed because the density is less than that of the emitted vapours. These are the ones most generally known. (2) Reversals in which there is little or no expansion of the lines, the background being either the hot walls and end of the tube, the hot pole of the arc, or such part of the spectrum which is so full of lines as to be nearly continuous. Photographs exhibiting the reversals of the lines of iron and other metals, were shown. (3) Reversals in which the background is produced by the expansion of a line of some other metal. Photographs were shown in which the lines of iron and other metals were seen reversed on the expanded lines of magnesium. (4) Reversals produced by the introduction into the crucible in which the arc was of a gentle current of hydrogen, coal gas or ammonia, by which means the metallic lines were almost swept away and the continuous spectrum increased. (5) When a carbon tube passed through a perforation in a block of lime is made the positive electrode of the arc, and a carbon rod passed into another perforation so as to meet the tube in the centre of the block, be made the negative electrode, the tube becomes gradually heated up, and in the direct line of the tube the lines are seen bright, because there is no background, but are seen reversed against the hot walls of the tube. Further the effects of the gradual increasing temperature were traced, as the tube was gradually heated. (6) A double reversal of lines is occasionally observed, and an instance was shown, in which the expansion of the magnesium lines between K and H, had taken place to such an extent as to produce the reversal of the most refrangible of the cyanogen bands; the magnesium producing a broad absorption band against which the magnesium triplet stood out bright and sharp. It is probable that this arises from the less dense but intensely heated magnesium vapour being pushed forward up the tube by the sudden burst of vapour produced when a fresh piece of metal is dropped into the arc.

On the Legal Flashing Test for Petroleum, by F. A. Abel, C.B., F.R.S.—The defects of the old legal flashing test, called the open test, and the test used in the United States, known as the fire-test, led to the introduction of the close-flashing test, which was legalised by Act of Parliament in 1879. The author exhibited the apparatus required, and described the method of using this test. This test has since been adopted in Germany and the United States, and the investigations conducted in the former country by Dr. Foerster and others, showed what had already been observed by the author, that the results obtained with the apparatus were influenced by atmospheric pressure. The most

recent investigations of the author and Mr. B. Redwood, have shown that a variation in the height of the barometer of one inch, was sufficient to produce a change of two degrees Fahrenheit in the flashing point of one and the same sample of oil. Further, it appears that the changes of atmospheric temperature have some influence on the flashing point of a sample of oil, and not only is it necessary to cool down the sample of oil immediately before testing it, when its temperature exceeds 65° F., but it is imperative, in cases where the oil has been stored in localities, the temperature of which is above 65° F., to maintain the oil at a low temperature for a considerable period before testing it. In consequence of this effect of changes of atmospheric temperature, some difficulties have arisen in applying this test in India, and investigations are at present being conducted, the object of which is to ascertain the conditions required for securing the attainment of trustworthy results by the application of this test in tropical climates.

On the Boiling Points and Vapour Tensions of Mercury, of Sulphur, and of some Compounds of Carbon, determined by means of the Hydrogen Thermometer, by Professor J. M. Crafts.—A description was given of the hydrogen thermometer used, the replacement of air by hydrogen was adopted because of the more rapid flow of hydrogen through a capillary tube, further, the bulb of the thermometer could be reduced from 200-500 cc. to 1-10 cc. The thermometer was one of constant volume in which an electric contact between the mercury in the manometer and a platinum point causes a current to excite a magnet and close a cock to arrest the flow of mercury into the manometer tube at the moment the gas attains a fixed volume, as determined by the surface of the mercury touching the platinum point. The boiling point of mercury has been redetermined, and found to be 357° (at the normal pressure), that of sulphur was found to be one degree lower than that assigned to it by Regnault. Naphthalene b. p. 218.08 (bar. 760 mm.), and benzophenone, b. p. 306.1° C. (bar. 760 mm.), were also used to obtain constant temperatures near 200° and 300°. The boiling points of these two substances were determined under reduced pressures varying from 87 to 2,300 mm., giving a series of temperatures that can be easily established and maintained for any length of time, and ranging from 140° to 350°. It is probable that benzene may be easily obtained sufficiently pure to be used in a similar manner. A series of determinations of the boiling points of several carbon compounds have been made, from which it appears that successive, similar additions to the molecular weight do not cause the boiling points to rise by a constant quantity as supposed by Kopp, but that in a large number of cases the increments to the boiling temperatures diminish by a constant quantity.

The Velocity of Explosion of a Mixture of Carbonic Oxide and Oxygen, with varying quantities of Aqueous Vapour, By H. B. Dixon, M.A.—The author has compared the velocities of explosion of mixtures of carbonic oxide and oxygen with varying quantities of aqueous vapour, by observing the pressure registered in a mercurial gauge attached to the endiometer in which the gases were fired. In each experiment the same mass of carbonic oxide and oxygen was exploded at nearly constant volume and temperature. The gauge was U shaped and contained air in the closed limb. An index similar to that used in Six's thermometer was carried up and left at the highest point reached by the mercury. Near the bend of the gauge two bulbs were blown to act as reservoirs, enabling the mercury to be lowered in the endiometer, without allowing air to escape from the closed limb. The endiometer was dried at 80° by drawing through it, for half an hour, air which had passed through tubes containing sulphuric acid, and a tube containing phosphoric pentoxide. It was found that in this way just sufficient aqueous vapour remained in the tube to enable the explosion to take place slowly when the sparks from a Ruhmkorff coil was passed through the mixed gases. In the first experiments several sparks were passed before the gases took fire. Experiments were made in which measured quantities of aqueous vapour were added, and the vapour kept below saturation, and also with the gases saturated with moisture. The results obtained in these experiments show the pressure registered to increase with the amount of moisture present in the gases, and to be the greatest when the gases are saturated.

On the Activity of Oxygen, and the mode of formation of Hydrogen Dioxide, by C. T. Kingzett, F.I.C., F.C.S.—An account is given of the various views held regarding the formation of ozone and hydrogen peroxide by slow oxidation, in the formation of the latter by the slow oxidation of the terpenes, the author considers that an organic peroxide is first formed,